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EVALUATION OF THE NRC 1996 FEED REQUIREMENTS FOR WINTERING BEEF COWS - ARE WE OVER-FEEDING OUR COWS?

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Evaluation of the NRC 1996 Feed Requirements for Wintering Beef Cows – Are we Over-Feeding our Cows?

ADF Project # 20020020

Final Report

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By

H. C. Block[1], J. L. Bourne[1], H. A. Lardner[2], and J. J. McKinnon[1]

[1]University of Saskatchewan, Saskatoon, SK, Canada

[2]Western Beef Development Centre, Humboldt, SK, Canada

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Executive Summary:

This final report provides detailed information on the complete results of the project, which formed the basis of a M.Sc. program for Miss. Jodi Bourne (defended February, 2007) in the Department of Animal and Poultry Science at the University of Saskatchewan.

The objects of the project were to:

1. compare actual dry matter intake and weight gains of wintering beef cows to that predicted by the NRC 1996 / "Cowbytes" ration formulation/prediction programs.

2. determine the winter feed requirements of cows in good body condition during the second and third trimesters when fed under Saskatchewan conditions.

3. use the results to make recommendations to nutritionists and livestock agrologists to refine the computer prediction software such as ""Cowbytes" for formulating diets for beef producers.

In order to achieve these objectives, in October in each of 3 years (2002/03, 2003/04) and 2004/05) 90 black Angus cows (average weight 1275 lbs) were selected from the Western Beef Development Centre's herd at Lanigan, Saskatchewan. In each year, the cows were conditioned scored (1-5) and pregnancy tested. Ultrasound was also used to measure body fat stores. The cows were sorted into 3 groups of 30 cows based on expected calving date. These included early, intermediate and late calving groups. Each group was randomly assigned to 5 pens (6 cows per pen / 5 pens per calving group) for winter feeding. Data collection included pen DMI, individual cow weights, body condition scores, calving dates and weights, and daily temperature and wind speed. Diet energy density was estimated from nutrient analysis of composited weekly feed samples.

The winter feeding program was broken up into two periods. These included:

1. November through beginning of 3rd trimester;
2. 3rd trimester through calving.

The object of the feeding program in the 2nd trimester was to maintain body weight and condition of the cows as per normal feeding management recommendations. Rations in year 1 included free choice access to a total mixed ration consisting of 54% (as fed basis) processed barley greenfeed (68% TDN and 12.3% CP) and 46% (as fed basis) oat straw (46% TDN and 4.2% CP). Free choice mineral (1:1) and trace mineral salt was provided throughout the trial in mineral feeders.

For the last 6 to 8 weeks prior to calving, the diet was changed to 63% alfalfa hay (62% TDN & 15% CP), 26% oat straw (46% TDN & 4.2 % CP) and 11% barley grain. The cows had free choice access to feed and mineral during this period, while a booster shot of ADE and Scourgaurd was provided approximately 6 weeks prior to calving. Similar feeding regimes are being used in years 2 and 3.

During the spring / early summer of years 1 and 2, a digestibility trial was carried out in the

metabolism barn of the Department of Animal and Poultry Science in order to determine digestible energy content of the wintering rations. In terms of our primary objective of determining the accuracy of the "NRC" model for predicting winter feed requirements of pregnant beef cows in western Canada the following comparisons were made:

1. Actual vs. predicted dry matter intake of cows;
2. Actual vs. predicted body weight gains;
3. Actual vs. predicted change in body condition scores.

Evaluations compared observed and predicted DMI and conceptus corrected ADG for the second and third trimesters using regression, means comparison, concordance correlation coefficient (CCC), and 90% total deviation index (TDI_{90}) methods. Across all three years, second trimester DMI was over predicted ($P<0.01$) with low precision (CCC = 0.24, TDI_{90} = n/a) using actual environmental conditions, but not ($P=0.34$) when assuming thermal neutral (TN) conditions, although precision remained low (CCC = 0.25, TDI_{90} = 1.91 kg/d). Third trimester DMI was also over predicted ($P<0.01$) with low precision (CCC = 0.12, TDI_{90} = 1.57 kg/d) using actual environmental conditions, but was largely under predicted ($P<0.01$) with worse precision (CCC = -0.01, TDI_{90} = 2.34 kg/d) when assuming TN conditions. Across all three years, second trimester ADG was largely under predicted ($P<0.01$) with low precision (CCC = 0.50, TDI_{90} = 0.58 kg) using actual environmental conditions, but over predicted ($P<0.01$) with similar precision (CCC = 0.51, TDI_{90} = 0.50 kg) when assuming TN conditions. Third trimester ADG predictions using actual environmental conditions were inaccurate ($P<0.01$) with low precision (CCC = 0.20, TDI_{90} = 0.70 kg) and worsened (CCC = -0.01, TDI_{90} = n/a) when assuming TN conditions where ADG was over predicted ($P<0.01$). These results indicate a lack of accuracy and precision with the current NRC (1996) model energy requirement and DMI equations that was not addressable by assuming TN conditions. Future research should be targeted at alternate DMI equations and refinements to maintenance and gain requirements.

In summary, this evaluation of NRC (1996, 2000) model energy requirement and DMI equation for wintering beef cows in western Canada found the equations to lack accuracy and precision in prediction of intake and gain. This situation was not resolved by removing the impact of the environment based adjusters by assuming thermal neutral conditions and calls into question the practical applicability of the equations for use in beef cow feeding management. There are several possible areas where improvements could be made in the predictions of intake and gain of beef cows. These include development of equations that are more reflective of the limitations to DMI by cows (i.e. fill effects instead of chemo-osmotic effects); maintenance energy requirement equations that are specific to cows instead of using equations adapted from feedlot cattle, and gain prediction equations that reflect that the composition of gain changes with cow condition. These are all issues that have not been addressed in the current energy requirement and intake equations. The inability of the current equations to accurately and precisely predict intake and gain of wintering beef cows should not be viewed as a failure, but rather a success in providing direction for future research. Many of the issues discussed as limitations to the model equations exist only because there is a lack of quality data available for resolving them.

Methodology and Results: The following is a complete presentation of materials and methods and results and is presented in a form that will be submitted to the Journal of Animal Science for publication purposes.

Title: Evaluation (accuracy and precision) of the NRC (1996, 2000) model for prediction of energy requirements and dry matter intake of wintering beef cows in western Canada.

Abstract

Three years of winter feeding trials using 90 Angus cows (15 pens of six) fed typical wintering diets formulated to stage of pregnancy were used to evaluate NRC (1996) energy requirement and DMI equation accuracy and precision. Data collection included pen DMI, individual cow weights, body condition scores, calving dates and weights, and daily temperature and wind speed. Diet energy density was estimated from nutrient analysis of composited weekly feed samples. Equation evaluations compared observed and predicted DMI and conceptus corrected ADG for the second and third trimesters using regression, means comparison, concordance correlation coefficient (CCC), and 90% total deviation index (TDI_{90}) methods. Across all three years, second trimester DMI was over predicted ($P<0.01$) with low precision (CCC = 0.24, TDI_{90} = n/a) using actual environmental conditions, but not ($P=0.34$) when assuming thermal neutral (TN) conditions, although precision remained low (CCC = 0.25, TDI_{90} = 1.91 kg/d). Third trimester DMI was also over predicted ($P<0.01$) with low precision (CCC = 0.12, TDI_{90} = 1.57 kg/d) using actual environmental conditions, but was largely under predicted ($P<0.01$) with worse precision (CCC = -0.01, TDI_{90} = 2.34 kg/d) when assuming TN conditions. Across all three years, second trimester ADG was largely under predicted ($P<0.01$) with low precision (CCC = 0.50, TDI_{90} = 0.58 kg) using actual environmental conditions, but over predicted ($P<0.01$) with similar precision (CCC = 0.51, TDI_{90} = 0.50 kg) when assuming TN conditions. Third trimester ADG predictions using actual environmental conditions were inaccurate ($P<0.01$) with low precision (CCC = 0.20, TDI_{90} = 0.70 kg) and worsened (CCC = -0.01, TDI_{90} = n/a) when assuming TN conditions where ADG was over predicted ($P<0.01$). These results indicate a lack of accuracy and precision with the current NRC (1996) model energy requirement and DMI equations that was not addressable by assuming TN conditions. Future research should be targeted at alternate DMI equations and refinements to maintenance and gain requirements.

Introduction

Previous evaluations of the National Research Council (NRC; 1996, 2000) beef model (Block et al. 2001, 2006) have found the model to lack accuracy, but have been focused on evaluation of feedlot cattle performance. Evaluations of model intake and gain predictions for wintering beef cows are not readily available. The objective of this project is to evaluate the NRC (1996, 2000) beef model with regard to its ability to predict the feed intake and weight change of Canadian beef cows during the winter feeding period, and if necessary once the model evaluation is complete, to provide suggestions for refining the model equations to more accurately predict feed intake and weight changes.

To more facilitate this objective, the model equations from the NRC beef model (1996, 2000) that specifically applied to non-lactating, pregnant cows were entered into a MS Excel spreadsheet. Use of this format has the distinct advantage of allowing more rapid modeling of large datasets, and will also allow modifications to be made to the equations used during the refinement phase of the project. Additionally, this format allows the evaluation to focus more specifically on the animal side of the NRC (1996, 2000) equations. Given the frequently limited nature of diet analysis available from historical data sets, including most of the ones available for these evaluations, the Level 2 approach to nutrient supply modeling which is based on the Cornell Net Carbohydrate and Protein System (CNCPS; Fox et al. 1992; O'Connor et al. 1993; Pitt et al. 1996; Russell et al. 1992; Sniffen et al. 1992) was not included. The nutrient supply modeling is more comparable to the Level 1 approach where the user specifies an energy density for the diet, and optionally a crude protein (CP) and degradable/undegradable intake protein (DIP/UIP) balance. Energy is entered either on the basis of total digestible nutrients (TDN), digestible, metabolizable, or net energy (DE, ME, NE). The CP values are optional as the NRC (1996, 2000) equations are focused on energy first and protein second. Failure to enter CP values merely limits evaluation to the accuracy of energy modeling and the assumption that the cattle have received adequate protein. Additionally, there is the option to predict energy content of the feed based on acid detergent fibre (ADF) content and Pennsylvania State equations from the National Forage Testing Association (NFTA 1993). A separate MS Excel spreadsheet was set up with additional feed energy content prediction equations (Goering and Van Soest 1970; Weiss et al. 1992) for use when more detailed feed analysis data are available.

Materials and Methods

The Saskatchewan data sets are from 2002-2003, 2003-2004, and 2004-2005 winter feeding trials conducted at the Termuende Research Farm near Lanigan, SK by researchers at the University of Saskatchewan. Each of these winter feeding trials began with 15 pens of 6 of mature commercial Angus cows. All cows were pregnancy checked at the beginning of the trial which allowed the cows to be managed in early, mid, and late calving groups and to divide the winter feeding period in to two evaluation periods. The first period roughly corresponded to the 2nd trimester and began November 5 for the 2002-2003 winter feeding trial, November 4 for the 2003-2004 winter feeding trial, and November 9 for the 2004-2005 winter feeding trial and ended approximately eight weeks before calving. The second period roughly corresponded to the 3rd trimester and began approximately 8 weeks before calving and ended approximately 2 weeks before calving. Trial and 3rd trimester evaluation period end dates varied with pen and year but ranged from March 23 to May 5.

The first two years of these data were used for a M.Sc. project by J. Bourne evaluating the accuracy of the CowBytes software program from Alberta Agriculture, which was based on the NRC (1996, 2000) model equations. For the current project, all three years of data have been used in evaluating the accuracy of intake and gain predictions made by the specific subset energy based equations of NRC (1996, 2000) appropriate for mature cows. Evaluations were carried out separately for each of the two periods, both individually and collectively for the three trials.

Housing and Feeding

All cattle were housed in outdoor 7.4 m by 24.5 m pens with a feed bunk running along the short southern edge of the pens, and a 20% porosity windbreak 2.4 m beyond the northern edge of the pens. Cattle were bedded twice weekly with woodchips and provided additional straw bedding for comfort to offset inclement conditions when deemed appropriate by the herdsperson.

Cattle were fed total mixed rations formulated to meet their nutrient requirements (NRC 1996, 2000) once daily. *Ad libitum* intake should have resulted in zero weight gain beyond that associated with fetal growth and feed supplied was 5 to 10% in excess of this amount. Feed bunks were cleaned weekly to track feed refusals. An early gestation ration based on barley

green feed and oat straw, and a late gestation ration based on alfalfa hay, barley grain, and oat straw were used, and cattle had *ad libitum* access to mineral supplements (Table 1). Nutrient content of diets are also presented in Table 1 and were used to estimate diet TDN according to Weiss et al. (1992). Transition between use of early and late gestation rations did not match the transition between 2nd and 3rd trimester evaluation periods.

Data Collection and Calculations

Cows were weighed individually before feeding on two consecutive days at the beginning and end of the trial, and every three weeks during the course of the trial. Cow weights were adjusted for conceptus weight according to NRC (2000) before determining ADG or shrunk body weights for model inputs using the following equation:

CW, kg

$$= 0.01828\ \text{CBW} \times e^{(0.02 \times t - 0.0000143 \times t^2)}$$

Where:

CW is conceptus weight in kg,

CBW is calf birth weight in kg, and

t is days pregnant.

It is important to note that the NRC (1996) has a decimal place shift that results in unrealistic conceptus weights.

Equations used for evaluation were all from NRC (1996, 2000) and are represented for clarity. The first set of calculations involved conversion of dietary TDN values to NE_m values:

DE, Mcal kg^{-1}

$$= 4.409\ \text{TDN}$$

ME, Mcal kg^{-1}

$$= 0.82\ \text{DE}$$

NE_m, Mcal kg^{-1}

$$= 1.37\ \text{ME} - 0.138\ \text{ME}^2 + 0.0105\ \text{ME}^3 - 1.12$$

Where:

DE is digestible energy in Mcal kg^{-1},

ME is metabolizable energy in Mcal kg^{-1}, and

NE_m is net energy for maintenance in Mcal kg^{-1}.

After calculation of NE_m, intake was estimated for non-lactating pregnant cows in their last two thirds of pregnancy.

DMI, kg d^{-1}

$= SBW^{0.75} ((0.04997\ NE_{ma}^2 + 0.04361) \div NE_{ma}) \times TEMP \times MUD$

Where:

SBW is shrunk body weight in kg after correction for conceptus,

NE_{ma} is net energy for maintenance available from the diet in Mcal kg^{-1},

TEMP is an adjustment based on temperature where intake is increased by 16% when temperature is below -5 °C, increased by 5% when temperature is between -5 and 5 °C, increased by 3% when temperature is between 5 and 15 °C, or decreased by 10% when temperature is above 25 °C, and

MUD is an adjustment based on mud depth where intake is decreased by 15% when mud depth is between 10 and 20 cm or decreased by 30% when mud depth is between 30 and 60 cm.

The calculation of intake was subject to the limitation that if diet NE_{ma} is <1.00 Mcal kg^{-1}, then diet NE_{ma} is set at 0.95 Mcal kg^{-1}. Intake estimation was followed by estimation of NE_m requirements without accounting for any possible acute cold stress effects.

NE_m, Mcal d^{-1}

$= (0.077 + 0.0007\ (20 - T_p))\ SBW^{0.75}\ (0.8 + ((CS - 1) \times 0.05)$

Where:

T_p is an acclimation adjustment to NE_m requirements based on previous temperature in °C,

SBW is shrunk body weight in kg after correction for conceptus, and

CS is an adjustment based on body condition score (9-point scale).

This initial NE_m requirement is then used to estimate the lower critical temperature of the cattle and determining if additional energy will be required to offset acute cold stress. These calculations also require estimation of the NE_m required for pregnancy.

NE_{preg}, Mcal d^{-1}

$$= CBW \times (k_m \div 0.13) \times (0.05855 - 0.0000996 \times t) \times e^{((0.03233 - 0.0000275 \times t) \times t)} \div 1000$$

Where:

CBW is calf birth weight in kg,

k_m is diet NE_m ÷ diet ME, and

t is the day of pregnancy.

Lower critical temperature estimation is based on a comparison of cattle surface area and normal heat production relative to cattle external and tissue insulation. First is the calculation of surface area.

SA, m^2

$$= 0.09\ SBW^{0.75}$$

Where:

SBW is shrunk body weight in kg after correction for conceptus.

Surface area calculations are followed by estimation of heat production.

HE, Mcal m^{-2} d^{-1}

$$= (MEI - (NE_m + NE_{preg})) \div SA$$

Where:

MEI is metabolizable energy intake in Mcal d^{-1},

NE_m is net energy requirement for maintenance before cold stress in Mcal d^{-1},

NE_{preg} is net energy requirement for pregnancy in Mcal d^{-1}, and

SA is surface area in m^2.

After heat production is estimated, then estimates are made of external insulation.

EI, °C $Mcal^{-1}$ m^2 d^1

$= (7.36 - 0.296\ WIND + 2.55\ HAIR) \times MUD \times HIDE$

Where:

WIND is wind speed in km h^{-1},

HAIR is effective hair depth in cm,

MUD is an adjustment factor for hide condition where external insulation is decreased by 20% if there is some mud on the lower body, decreased by 50% if the hide is wet and matted, and decreased by 80% if the hide is covered with wet snow or mud, and

HIDE is an adjustment factor where external insulation is increased by 20% if the cattle have Hereford breeding.

External insulation estimation is followed by tissue insulation estimation.

TI, °C $Mcal^{-1}$ m^2 d^1

$= 5.25 + (0.75 \times CS)$

Where:

CS is body condition score (9-point scale).

Lower critical temperature can then be estimated based on total insulation and heat production.

LCT, °C

$= 39 - (EI + TI) \times HE \times 0.85$

Where:

EI, is external insulation in °C $Mcal^{-1}$ m^2 d^1,

TI, is tissue insulation in °C $Mcal^{-1}$ m^2 d^1, and

HE is heat production in Mcal m^{-2} d^{-1}.

If the current temperature is lower than this estimated lower critical temperature, then it

is necessary to estimate then NE_m required to offset acute cold stress.

NE_{mcs}, Mcal d^{-1}

$= k_m (SA (LCT - T_c) \div (EI + TI))$

Where:

k_m is diet NE_m ÷ diet ME,

SA is surface area in m^2,

LCT is the lower critical temperature in °C,

T_c is the current temperature in °C,

EI, is external insulation in °C $Mcal^{-1}$ m^2 d^1, and

TI, is tissue insulation in °C $Mcal^{-1}$ m^2 d^1.

At this point, the NE_m requirements for maintenance without cold stress, pregnancy, and any effect of cold stress can be subtracted from total NE_m intake and weight gain or loss can be estimate based on any surpluses or deficiencies in energy intake.

ADG, kg d^{-1}

$= ((DMI \times NE_{ma}) - (NE_m + NE_{preg} + NE_{mcs})) \div 5.82$

Where:

DMI is DM intake in kg d^{-1},

NE_{ma} is net energy for maintenance available from the diet in Mcal kg^{-1},

NE_m is net energy requirement for maintenance before cold stress in Mcal d^{-1},

NE_{preg} is net energy requirement for pregnancy in Mcal d^{-1}, and

NE_{mcs} is net energy requirement for maintenance due to acute cold stress in Mcal d^{-1}.

In the case of a predicted deficient energy intake, the prediction of ADG needs to be modified to reflect the lower efficiency of mobilizing tissue reserves to meet NE requirements. This is done by dividing negative predictions of ADG by 0.8.

Model Inputs

While taken directly from the published NRC (1996, 2000) model prediction equations, it

is important to note that the relatively narrow focus of this current study allowed many of the equations to be simplified. For example, with all of the cattle in these studies being non-lactating Angus cows, the breed, lactation, and gender effect modifiers for estimation of NE_m requirements could be dropped. Additionally, by focusing only on the cattle energy requirement equations, the number of inputs required to generate predictions were also greatly reduced. Required dietary inputs consisted of information on DMI, TDN, and use of an ionophore. Both DMI and TDN data are summarized in Table 2, and none of the diets fed contained an ionophore.

Required environmental information included existence of night cooling to offset heat stress, pen mud depth as a modifier on intake, previous and current temperature, wind speed, effective hair depth, and effect of hide condition and thickness on external and tissue insulation. With these winter feeding trials, night cooling to offset heat stress was not a factor in the model predictions. Likewise, generally frozen pen conditions removed pen mud depth as a modifier of intake. Previous temperatures are summarized in Table 2 and were taken as the average temperature for a time period as long as the 2nd or 3rd trimester evaluation periods, but starting 28 d earlier. Current temperatures and wind speed were the averages over the feeding periods and are also summarized in Table 2. Wind speeds were reduced to on third of their original values to reflect the sheltering effects of windbreaks. Effective hair depth was set to the NRC (1996, 2000) model suggest default of 1.27 cm. With Angus cattle hide thickness does not affect tissue insulation, and the generally frozen conditions of these feeding trials remove hide condition as a modifier of external insulation. Evaluations were also carried out assuming thermal neutral conditions by using previous and current temperatures of 20°C and a wind speed of 0 km/h.

Tissue insulation value determination changes with animal age up to 1 year after which cattle of all ages are dealt with similarly. With this study focusing on mature cows, exact animal age would not affect predictions of intake or gain. Details on shrunk body weights after adjusting for conceptus weight, body condition scores (9-point scale), days pregnant, and calf birth weight are all summarized in Table 2. The shrunk body weight, body condition scores, and days pregnant all represent averages over the evaluation period. Observed ADG is also presented in Table 2.

Statistical Analyses

Statistical analyses for evaluation of NRC (1996, 2000) model DMI and energy requirement equation accuracy and precision involved a variety of methods to ensure that any deficiencies identified with one method would be covered through application of another method.

Evaluation of accuracy began with regression of observed and predicted DMI or ADG. Statistics noted included intercept and slope estimates and standard errors, the coefficient of determination (R^2; proportion of variation in observed DMI or ADG explained by predicted DMI or ADG) and root mean square error ($s_{y.x}$; total deviation in observed DMI or ADG not explained by predicted DMI or ADG). Bias (absolute difference between means) was also noted and the mean square error of prediction was determined and partitioned into bias (difference between means), slope (difference from unity), and residual (random error or lack of correlation) components as described by Rice and Cochran (1984). The test for accuracy with regression of observed and predicted intakes or gains involved a comparison between the fitted regression relationship and the isopleth (observed = predicted). Identification of a difference ($P<0.05$) between the fitted regression relationship and the isopleth indicates inaccurate prediction whereas failure to identify any difference ($P>0.05$) leads to acceptance of model accuracy. However, this test is only valid if there is a relationship ($P<0.05$) between observed and predicted DMI or ADG.

If there was no regression relationship ($P<0.05$), residuals (predicted – observed) were regressed on predicted DMI and ADG. Again, statistics noted included intercept and slope estimates and standard errors, the coefficient of determination (proportion of variation in residual DMI or ADG explained by predicted DMI or ADG) and root mean square error (total deviation in residual DMI or ADG not explained by predicted DMI or ADG). In this case, the existence ($P<0.05$) of any regression relationship indicates inaccurate prediction. However, failure ($P>0.05$) to identify a relationship between residuals and predicted DMI and ADG is considered inconclusive and does not ensure accuracy.

In the event that regression of both observed and residual DMI and ADG on predictions were inconclusive, means comparison of observed and predicted DMI or ADG was the final evaluation of accuracy. Predicted values were designated as the independent variable for all regression analyses as there is no experimental uncertainty associated with predicted DMI or ADG once model inputs are specified.

Evaluation of precision also involved several different methods including the concordance correlation coefficient (CCC), the 90% total deviation index (TDI_{90}), and coverage probability (CP) tests as described by Lin (1992, 2000) and Lin et al. (2002). The CCC is the product of accuracy (correlation between regression estimates and model predicted DMI or ADG) and precision (correlation between observed and predicted ADG or DMI) correlation coefficients. A CCC value of 1 indicates perfect agreement, 0 indicates no agreement, and -1 indicates perfect disagreement between observed and predicted DMI or ADG. The TDI_{90} represents absolute difference between individual pen observed and predicted DMI or ADG for which 90% of the pens would have a lower value. The TDI_{90} statistic contrasts with the CP statistic which is the proportion of data where the difference between observed and predicted values falls within a pre-specified absolute difference. For these evaluations, selected CP limits were 1.0 kg d^{-1} for DMI and 0.25 kg for ADG. To protect against type II errors, both the TDI_{90} and CP statistics are considered appropriate only if the relative bias square statistic is ≤ 1.

All analyses except the mean square error partitioning were carried out using SAS (SAS Institute Inc., Cary NC) regression or mixed models procedures or a macro provided by L. Lin (Baxter Health Care Corp., Round Lake, IL). The mean square error partitioning was done manually.

Results and Discussion

Accuracy and precision of DMI predictions for the 2nd trimester evaluation period

Figure 1 is a plot of observed vs. predicted DMI under actual environmental conditions for the 2nd trimester evaluation period of all three trials. Perfectly accurate prediction would occur if all plotted data points fell on the isopleth (solid line). Deviation from this would represent a lack of precision only as long as the fitted regression equation (dashed line) remained equal to the isopleth. Deviation between the fitted regression equation and the isopleth represents a lack of accuracy. Model evaluation statistics shown relate to the combined analysis of all three years of data using regression of observed vs. predicted DMI.

When the DMI data for each year was evaluated individually using the actual environmental conditions (Table 3), there was no relationship (P=0.49) between observed and predicted DMI for the 2nd trimester of the 2002-2003 winter feeding period making this method an inconclusive test of accuracy. Predicted DMI explained only 4% of the variation in observed

DMI with a $s_{y.x}$ of 0.45 kg d^{-1}. Regression of residual vs. predicted DMI was also inconclusive with no relationship being found (P=0.57). However, comparison of observed and predicted DMI means found DMI to be over predicted (P<0.01) by 18%. The CCC of 0.01 indicates almost no agreement between observed and predicted DMI for the 2nd trimester of the 2002-2003 winter feeding period and the relative bias square value of 18.18 exceeded 1, invalidating the TDI_{90} and CP statistics.

There was also no relationship (P=0.60) between observed and predicted DMI for the 2nd trimester of the 2003-2004 winter feeding period with a $s_{y.x}$ of 0.80 kg d^{-1} and only 2% of the variation in observed DMI being explained by predicted DMI. Regression with residuals was also inconclusive (P=0.97) although means comparisons found DMI to be over predicted (P=0.01) by 14%. Again, The CCC of 0.01 indicates almost no agreement between observed and predicted DMI for the 2nd trimester of the 2003-2004 winter feeding period and the relative bias square value of 3.59 exceeded 1, invalidating the TDI_{90} and CP statistics.

For the 2nd trimester evaluation period of the 2004-2005 winter feeding trial, predicted DMI explained (P<0.01) 50% of the variation in observed DMI with a $s_{y.x}$ of 0.75 kg d^{-1}. However, the fitted relationship differed (P<0.01) from the isopleth indicating inaccurate prediction with 48% of the inaccuracy due to bias, 14% due to slope, and 38% due to residual sources. Intake was generally over predicted. There was very weak agreement between observed and predicted DMI as evidenced by a CCC of 0.22. Lack of agreements was further supported by both the large TDI_{90} of 1.99 kg d^{-1} and the fact that only 55% of the pens of cows would be expected to have observed and predicted DMI agreeing within the limit of 1 kg d^{-1}.

When the data for the 2nd trimester of all three years was evaluated collectively (Table 3), predicted DMI explained 69% of the variation in observed DMI with a $s_{y.x}$ of 0.68 kg d^{-1}. However, these predictions were inaccurate (P<0.01) with a general over prediction of DMI and 74% of the inaccuracy due to bias, 10% due to slope, and 16% due to residual sources. The agreement between observed and predicted DMI remained weak with a CCC of 0.24 while the relative bias square of 2.83 exceeded 1 and invalidated the TDI_{90} and CP statistics.

One possible cause for the over prediction of DMI observed for the 2nd trimester evaluation period of all three years of winter feeding trials is that predicted DMI is increased with colder environments. For the 2nd trimester evaluation period, this would have resulted in a 16% increase in predicted DMI for all three years of the winter feeding trials. Re-evaluating the

DMI predictions under the assumption of thermal neutral conditions removes the effect of this adjuster.

When the data from each year were re-evaluated under the assumption of thermal neutral environmental conditions (Table 4), there was still no relationship (P=0.27) between observed and predicted DMI for the 2nd trimester of the 2002-2003 winter feeding period with predicted DMI explaining only 9% of the variation observed in DMI with a $s_{y.x}$ of 0.43 kg d^{-1}. However, a relationship (P<0.01) was found with regression of residual vs. predicted DMI indicating inaccurate prediction of DMI. Intake was generally over predicted with DMI predictions being able to explain 83% of the error in the prediction of DMI. There was a weak disagreement between observed and predicted DMI as indicated by a CCC of -0.16. The large TDI_{90} of 2.03 kg d^{-1} and low CP of 55% were further evidence of low agreement between observed and predicted DMI.

For the 2nd trimester of the 2003-2004 winter feeding period assuming thermal neutral conditions also failed (P=0.60) to find a relationship between observed and predicted DMI with predicted DMI explaining only 2% of the variation observed in DMI with a $s_{y.x}$ of 0.80 kg d^{-1}. There was also no relationship (P=0.92) between residual and predicted DMI and with predicted DMI being 98% of observed, the means did not differ (P=0.25) allowing the conclusion that prediction of DMI was accurate for the 2nd trimester of the 2003-2004 winter feeding period. The CCC of 0.03 indicates no agreement between predicted and observed DMI although the smaller TDI_{90} of 1.32 kg d^{-1} and larger CP of 75% do suggest that predictions were approaching a level of accuracy and precision that would support practical usage of model DMI predictions.

For the 2nd trimester of the 2004-2005 winter feeding trial, predicted and observed DMI were related (P<0.01) with predicted DMI explaining 51% of the variation in observed DMI with a $s_{y.x}$ of 0.75 kg d^{-1}. However, this relationship differed (P<0.01) from the isopleth leading to the conclusion of inaccurate prediction. Intake was generally under predicted with 61% of the inaccuracy due to bias, 13% due to slope, and 26% due to residual sources. There was little agreement between observed and predicted DMI as evidenced by a CCC of 0.15, and the relative bias square value of 1.35 was greater than 1, invalidating the TDI_{90} and CP statistics.

When data from all three years were evaluated collectively with the assumption of thermal neutral conditions (Table 4), there was a relationship (P=0.02) between observed and predicted DMI with predicted DMI explaining 12% of the variation in observed DMI with a $s_{y.x}$

of 1.14 kg d^{-1}. This regression relationship did not differ (P=0.34) from the isopleth allowing the conclusion of accurate prediction. Of the inaccuracy that did exist, 58% was due to bias, 1% due to slope, and 41% due to residual sources. However, the CCC of 0.25 suggests quite low agreement between observed and predicted DMI and was supported by the large TDI_{90} of 1.91 kg d^{-1} and that only 60% of the pens of cows would be expected to have difference between observed and predicted DMI of less than 1 kg d^{-1}.

Removing the temperature based adjustments to DMI predictions by assuming thermal neutral conditions did reduce the over prediction of DMI observed when actual environmental conditions were used. However, poor precision and agreement between observed and predicted DMI still limits the practical application of the NRC (1996, 2000) model predictions of DMI for wintering beef cows. It is important to note that while improvements in prediction accuracy were achieved by removal of the environmental effect components of the DMI prediction equation; this does not mean that these adjustments were responsible for the lack of accuracy and precision observed. The NRC (1996, 2000) model DMI prediction equation is based on SBW and diet energy density with diet energy values being set to fixed values with low energy diets. In the case of the 2nd trimester evaluation period, diet energy values were low enough that predicted DMI stops responding to changes in diet energy density and begin to be based on SBW only. While the NRC (1996, 2000) model DMI prediction equation does use diet energy density to reflect the scientific theory of that intake of high energy diets is limited by chemo-osmotic factors, there is no transition to any other form of prediction equation when diet energy density drops to the point where rumen fill or feed mastication time effects begin to be the DMI limiting factors. This observation suggest further research be directed to developing intake prediction equations based on factors other than diet energy density, especially in the case of wintering beef cows where chemo-osmotic factors are not expected to limit feed intake.

Accuracy and precision of DMI predictions for the 3rd trimester evaluation period

Figure 2 is a plot of observed vs. predicted DMI under actual environmental conditions for the 3rd trimester evaluation period of all three trials. Model evaluation statistics presented relate to the evaluation of all three years of data using regression of observed vs. predicted DMI approaches.

When the 3rd trimester of data for each year was evaluated individually (Table 5), DMI

predictions for the 2002-2003 winter feeding period were not (P=0.21) related to observed DMI invalidating regression of observed vs. predicted DMI as a test of accuracy. Predicted DMI explained only 12% of the variation in observed DMI with a $s_{y.x}$ of 0.88 kg d^{-1}. Regression of residual vs. predicted DMI also failed (P=0.57) to identify a relationship. Means comparison did find DMI to be over predicted (P=0.01) by 5%. Little agreement between predicted and observed DMI was further supported by the low CCC of 0.09, the large TDI_{90} of 1.78 kg d^{-1}, and the fact that only 61% of the pens of cows would be expected to have predicted and observed DMI to agree within 1 kg.

For the 3rd trimester of the 2003-2004 winter feeding period, there was again no relationship (P=0.72) between observed and predicted DMI with predicted DMI explaining only 1% of the variation in observed DMI although the $s_{y.x}$ was lower at 0.55 kg d^{-1}. There was also no relationship (P=0.24) between residual and predicted DMI. Means comparisons found predicted and observed DMI to be similar (P=0.36) with <1% under prediction suggesting accurate prediction of DMI. Additionally, although the CCC of -0.04 suggests no agreement between observed and predicted values, the TDI_{90} of 0.94 kg d^{-1} and the fact that 90% of the pens of cows are expected to have observed and predicted DMI to agree within 1 kg d^{-1} suggest the model predictions in this situation may have practical application.

With the 3rd trimester of the 2004-2005 winter feeding period, there was a relationship (P=0.02) between observed and predicted DMI whereby predicted DMI explained 35% of the variation in observed DMI with a $s_{y.x}$ of 0.53 kg d^{-1}. However, the fitted relationship differed (P<0.01) from the isopleth with a general over prediction of DMI. Of the inaccuracy observed, 79% was due to bias, 1% due to slope, and 20% due to residual sources. Agreement between observed and predicted DMI was low with a CCC of 0.20. The relative bias square of 3.30 was >1 invalidating the TDI_{90} and CP statistics.

When DMI data for the 3rd trimester of all three years were evaluated collectively (Table 5), there was no relationship (P=0.12) between observed and predicted DMI with predicted DMI explaining only 5% of the variation in observed DMI with a $s_{y.x}$ of 0.80 kg d^{-1}. There was also no relationship (P=0.21) between residual and predicted DMI. Means comparison found DMI to be over predicted (P<0.01) by 4%. The CCC of 0.12 suggests no relationship between observed and predicted DMI, and the relative large TDI_{90} of 1.57 kg d^{-1}, and the fact that <70% of the pens of cows evaluated would be expected to have observed and predicted DMI agreeing within 1 kg

d^{-1} limits the practical applicability of the DMI predictions.

Although cows experienced similar temperatures in both the 2nd and 3rd trimester evaluation periods of the first two years of the winter feeding trials and would have therefore had DMI predictions increased by 16% due to environment, cows in the third year of the winter feeding trial experienced warmer temperatures for the 3rd than the 2nd trimester evaluation period and would have only had DMI predictions increased by 5%. Once again, DMI predictions for the 3rd trimester of the winter feeding trials were re-evaluated under the assumption of thermal neutral conditions to remove the effect of these adjusters and determine if this would result in more accurate and precise estimates of DMI by wintering beef cows (Table 6).

For the 3rd trimester of the 2002-2003 winter feeding period, assuming thermal neutral conditions did not (P=0.10) result in a relationship between observed and predicted DMI. Predicted DMI explained only 20% of the variation in observed DMI with a $s_{y.x}$ of 0.84 kg d^{-1}. There was also no relationship (P=0.07) between residual and predicted DMI. Means comparison found DMI to be under predicted (P=0.03) by 6%. The CCC of 0.33 indicates low agreement between observed and predicted DMI, which is supported by the large TDI_{90} of 1.95 kg d^{-1} and the observation that only 57% of the pens of cows would be expected to have observed and predicted DMI agree within 1 kg d^{-1}.

For 2003-2004, there was no relationship (P=0.72) between observed and predicted DMI with predicted DMI explaining only 1% of the variation in observed DMI with a $s_{y.x}$ of 0.55 kg d^{-1}. There was also no relationship (P=0.29) between residual and predicted DMI although means comparison found DMI to be under predicted (P<0.01) by 15%. The CCC of -0.01 indicates no relationship between observed and predicted DMI. The relative bias square was 11.24 and invalidates the TDI_{90} and CP statistics.

There was no relationship (P=0.28) between observed and predicted DMI for the 3rd trimester of the 2004-2005 winter feeding period. Predicted DMI explained only 9% of the variation in observed DMI with a $s_{y.x}$ of 0.62 kg d^{-1}. There was also no relationship (P=0.17) between residual and predicted DMI. Means comparison found observed and predicted DMI to be similar (P=0.75) with <1% under prediction suggesting accurate prediction. The CCC of 0.28 indicates little agreement between observed and predicted DMI although the relatively low TDI_{90} of 1.07 kg d^{-1} and the expectation that 85% of the pens of cows would have observed and predicted DMI agreeing within 1 kg d^{-1} does suggest the potential for practical application of the

DMI predictions in this scenario.

When DMI data for the 3rd trimester of all three years were evaluated collectively, there was no relationship (P=0.94) between observed and predicted DMI. Predicted DMI explained <1% of the variation in observed DMI with a $s_{y.x}$ of 0.82 kg d^{-1}. There was a relationship (P<0.01) between residual and predicted DMI indicating inaccurate prediction of DMI. Intake was generally under predicted with predicted DMI being able to explain 43% of the variation in DMI prediction error.

The accuracy and precision of DMI predictions made for the 3rd trimester with actual environmental conditions were variable and would limit the practical application of these. This situation was not improved with the assumption of thermal neutral conditions and removal of the temperature adjustments with the net impact being to switch from over to under prediction of DMI. Several differences existed between the 2nd and 3rd trimester evaluation periods. The cows were in a more advanced stage of pregnancy, diets had been reformulated to supply more energy, and in at least one of the three years of data the cows were experiencing warmer temperatures. Any of these factors could have contributed to the difference in prediction accuracy between the two different trimesters. It is tempting to attribute the inaccuracies in the 3rd trimester to factors other than fill effect limitation of intake as the diets were more energy dense than those fed during the 2nd trimester. However, this may not be appropriate with late gestation cows and the results of the 3rd trimester can also call into question the appropriateness of a DMI prediction equation based on energy density when other factor may have limited intake.

Accuracy and precision of ADG predictions for the 2nd trimester evaluation period

Figure 3 is a plot of observed vs. predicted ADG under actual environmental conditions for the 2nd trimester evaluation period of all three trials. Model evaluation statistics presented relate to the evaluation of all three years of data using regression of observed vs. predicted ADG approaches. Both observed and predicted ADG reflect weight gain by cows in addition to the gains expected due to conceptus growth with advancing pregnancy.

When the 2nd trimester evaluation period was evaluated separately for each year using actual environmental conditions (Table 7), there was no relationship (P=0.30) between observed and predicted ADG for the 2002-2003 winter feeding period. Predicted ADG explained only 8%

of the variation in observed ADG with a $s_{y.x}$ of 0.09 kg. There was a relationship (P=0.01) between residual and predicted ADG indicating inaccurate prediction of ADG. There was a general under prediction of ADG with predicted ADG explaining 45% of the variation in ADG prediction error. The CCC of 0.03 indicated no agreement between observed and predicted ADG and the relative bias square of 7.95 was >1, invalidating the TDI_{90} and CP statistics.

For the 2nd trimester of the 2003-2004 winter feeding period there was no relationship (P=0.18) between observed and predicted ADG. Only 14% of the variation in observed ADG was explained by predicted ADG with a $s_{y.x}$ of 0.11 kg. The existence (P<0.01) of a relationship between residual and predicted ADG indicates inaccurate prediction. Again, there was a general under prediction of ADG with predicted ADG explaining 67% of the variation in ADG prediction error. The CCC of 0.08 again indicated no agreement between observed and predicted ADG and the relative bias square of 3.82 was >1 invalidating the TDI_{90} and CP statistics.

For the 2004-2005 winter feeding period there was a relationship (P<0.01) between observed and predicted ADG with predicted ADG explaining 52% of the variation in observed ADG with a $s_{y.x}$ of 0.10 kg. However, this relationship differed (P<0.01) from the isopleth indicating inaccurate prediction of ADG with 30% of the inaccuracy due to bias, 30% due to slope, and 39% due to residual error components. In this case, ADG was generally over predicted. However, the CCC of 0.60 indicate moderate agreement between observed and predicted ADG while the TDI_{90} of 0.27 kg and CP of 86% suggest that the predictions in this case may have enough accuracy to support practical application.

When the 2nd trimester data of all three winter feeding trials were evaluated collectively (Table 7), there was a relationship (P<0.01) between observed and predicted ADG with predicted ADG explaining 69% of the variation in observed ADG with a $s_{y.x}$ of 0.10 kg. However, this relationship differed (P<0.01) from the isopleth indicating inaccurate prediction of ADG. Of the inaccuracy observed, 42% was attributed to bias, 50% to slope, and 8% to residual error components. There was a general under prediction of ADG. The CCC of 0.50 supports moderate agreement between observed and predicted ADG. However, the TDI_{90} of 0.58 kg and the observation that <50% of the pens of cows would be expected to have observed and predicted ADG agree within 0.25 kg would limit practical application of these ADG predictions.

There are several possible reasons why ADG would be under predicted for the wintering

beef cows. Block et al. (2001) have suggested that with feedlot cattle the adjustments made to maintenance energy requirements in response to colder environmental conditions appear to be in excess of the thermal stress experienced by cattle and would to over estimation of maintenance energy requirements and subsequent under estimation of ADG. In their evaluations of feedlot cattle, Block et al. (2001) found that assuming thermal neutral conditions and removing the impact of environment on the maintenance energy requirements of steers did result in predictions of ADG that were closer to observed values. However, although the NRC (1996, 2000) model equations addressing the impact of environment on maintenance energy requirement do appear suspicious, the observations of Block et al. (2001) should not be taken as proof that this is a problem with ADG predictions, or that it is the only problem with ADG predictions.

The net energy system used by the NRC (1996, 2000) model is based on California feedlot steer data (Lofgreen and Garrett 1968; Garrett 1980) and the original base maintenance energy requirements were originally based on empty body weight. No adjustments were made to adjust the maintenance energy equations to use shrunk body weight, and there has apparently not been any evaluation specifically regarding the appropriateness of using maintenance energy equations derived from steer data for cows. These issues allow the equation for determining the maintenance energy requirement of cows to be called in to question independently of whether the impact of environment on maintenance energy requirements is estimated correctly.

Both of the two previous mentioned possible explanations for inaccurate ADG prediction affect predicted ADG only through their impact on maintenance energy requirements and subsequently the energy available for gain. There is also the potential that the equations predicting ADG from intake energy surplus to maintenance requirements could be flawed. With feedlot cattle, there ADG prediction equations take into account changes in the composition of gain that occur as cattle fatten by increasing the energy content of gain with increasing body weight and more rapid rates of gain to reflect the increased fat content of gain occurring in these situations. The equations predicting ADG of mature cows do not reflect any changes in body composition or the composition of gain. All mature cows are expected to gain 1 kg of SBW for every 5.82 Mcal of NE_m available in excess of maintenance, pregnancy, and lactation requirements. This expectation has obvious potential to contribute to inaccurate prediction of ADG with wintering beef cows.

With the previous feedlot based evaluations of ADG predictions (Block et al. 2001, 2006)

the relatively large observed and predicted ADG provided limited ability to narrow down possible causes of inaccurate ADG. However, with the current evaluation using wintering cows with substantially lower ADG than growing cattle, it was possible to specifically identify a problem with the prediction maintenance requirements when using actual environmental conditions. This stems from the observation that predicted ADG means for the 2002-2003 and 2003-2004 winter feeding trials were negative whereas observed ADG means were positive (Table 7). While this does not exclude a possible issue with the accuracy of the equation relating surplus energy intake to ADG, the only way in which cows can demonstrate positive ADG while being predicted to have negative ADG is for there to be an error in the prediction of amount of feed required for maintenance.

Re-evaluation of 2nd trimester ADG predictions under the assumption of thermal neutral conditions (Table 8) has the effect of removing the impact of suspect environmental effect equations. This has the potential to improve the precision and accuracy of ADG predictions, although improved predictions would still not necessarily serve as proof of inadequate environmental effect estimation.

With the assumption of thermal neutral conditions, there was no relationship (P=0.62) between observed and predicted ADG for the 2nd trimester of 2002-2003 with predicted ADG explaining only 2% of the variation in observed ADG with a $s_{y.x}$ of 0.10 kg. There was a relationship (P<0.01) between residual and predicted ADG indicating inaccurate prediction. Predicted ADG was able to explain 87% of the variation in the prediction error. There was still a general under prediction of ADG, although less than what had been observed when actual environmental conditions were used. The CCC of -0.10 indicates very weak disagreement between observed and predicted ADG. The TDI_{90} was 0.43 kg, and only 61% of the pens of cows would be expected to have observed and predicted ADG to agree within 0.25 kg.

For the 2nd trimester of the 2003-2004 feeding trial there was no relationship (P=0.09) between observed and predicted ADG. Predicted ADG explained 20% of the variation in observed ADG with a $s_{y.x}$ of 0.11 kg. There was a relationship (P=0.02) between residual and predicted ADG indicating inaccurate prediction of ADG. Predicted ADG explained 36% of the variation in ADG prediction error. ADG was generally over predicted, but to a lesser degree than the previous under prediction observed when using actual environmental conditions. The CCC of 0.26 indicates very little agreement between observed and predicted ADG and while the

relative bias square value of 1.07 is >1 and invalidates the TDI_{90} and CP statistics, the invalidation is marginal and if they are accepted, the TDI_{90} of 0.33 kg and the CP of 77% are approaching levels that would allow practical application of these ADG predictions.

For the 2004-2005 winter feeding trial, there was a relationship ($P<0.01$) between observed and predicted ADG with predicted ADG explaining 54% of the variation in observed ADG and a $s_{y.x}$ of 0.10 kg. This relationship did differ ($P<0.01$) from the isopleth indicating inaccurate prediction of ADG with 90% of the inaccuracy attributed to bias, 4% to slope, and 6% residual error. Gain was generally over predicted and the over prediction in this case was to a greater degree than observed when actual environmental conditions were used. The CCC of 0.19 indicates weak agreement between observed and predicted ADG with a relative bias square of 7.62 being >1 and invalidating the TDI_{90} and CP statistics.

When all three years of 2nd trimester ADG data were evaluated collectively under the assumption of thermal neutral conditions, there was a relationship ($P<0.01$) between observed and predicted ADG with predicted ADG explaining 54% of the variation in ADG with a $s_{y.x}$ of 0.13 kg. This relationship did differ ($P<0.05$) from the isopleth indicating inaccurate prediction of ADG with 30% of the inaccuracy due to bias, 53% due to slope, and 17% due to residual error components. Gains were generally over predicted, although to a lesser degree than the under predicted that occurred when using actual environmental conditions. The CCC of 0.51 suggests moderate agreement between observed and predicted ADG, although the TDI_{90} of 0.50 kg and expectation that only 57% of the pens of cows would have predicted and observed ADG agree within 0.25 kg do suggest that practical application of these ADG predictions would be limited.

The assumption of thermal neutral conditions for the 2nd trimester of the winter feeding trials resulted in predictions of ADG that were closer to observed ADF although they still lacked accuracy and precision. In all many cases where ADG was under predicted when using actual environmental conditions, ADG became over predicted when thermal neutral conditions were assumed. This suggests that the cows were affected by environmental conditions, but not a severely as suggested by the model equations. Unfortunately from a model evaluation viewpoint, when thermal neutral conditions were assumed all observed and predict ADG means were positive. Had any of the prediction means remained negative while the cows demonstrated positive gains, it would have been clear evidence that the base maintenance energy requirement equations were inaccurate. As this did not occur, no firm conclusions can yet be made regarding

where the inaccuracy in maintenance energy requirements lies.

Accuracy and precision of ADG predictions for the 3rd trimester evaluation period

Figure 4 is a plot of observed vs. predicted ADG under actual environmental conditions for the 3rd trimester evaluation period of all three trials. Model evaluation statistics presented relate to the evaluation of all three years of data using regression of observed vs. predicted ADG approaches. Both observed and predicted ADG reflect weight gain by cows in addition to the gains expected due to conceptus growth with advancing pregnancy.

When the 3rd trimester evaluation period was evaluated separately for each year using actual environmental conditions (Table 9), there was a relationship (P=0.01) between observed and predicted ADG for the 2002-2003 winter feeding period. Predicted ADG explained 41% of the variation in observed ADG with a $s_{y.x}$ of 0.10 kg. This relationship differed (P<0.01) from the isopleth indicating inaccurate prediction with 26% of the inaccuracy attributed to bias, 51% to slope, and 23% to residual error components. Gains were generally under predicted. The CCC of 0.46 suggests moderate agreement between observed and predicted ADG although the TDI_{90} of 0.32 kg and CP of 77% indicate practical applicability of these ADG predictions would be limited.

For the 2003-2004 winter feeding period, there was no relationship (P=0.96) between observed and predict ADG with predicted ADG explaining <1% of the variation in observed ADG and a $s_{y.x}$ of 0.14 kg. There was a relationship (P<0.01) between residual and predicted ADG indicating inaccurate prediction of ADG. Predicted ADG explained 49% of the variation in prediction error. Gain was under predicted with low predictions and over predicted with high predictions with observed and predicted ADG means being very similar. However, with CCC at -0.01 indicating no agreement between observed and predicted ADG and the TDI_{90} of 0.31 kg and CP of 78% indicate practical applicability of these ADG predictions would be limited.

With the 2004-2005 winter feeding period, there was no relationship (P=0.44) between observed and predicted ADG with predicted ADG explaining only 5% of the variation in observed ADG with a $s_{y.x}$ of 0.14 kg. There was a relationship (P<0.01) between residual and predicted ADG indicating inaccurate prediction of ADG with predicted ADG explaining 66% of the variation in ADG prediction error. Gain was generally over predicted with almost no relationship between observed and predicted ADG. The large TDI_{90} of 0.51 kg and the fact that

only 54% of the pens of cows would be expected to have observed and predicted ADG agree within 0.25 kg suggest these ADG predictions have limited value.

When all three years of 3rd trimester ADG data were evaluated collectively, there was no relationship (P=0.18) between predicted and observed ADG with predicted ADG explaining only 4% of the variation in observed ADG with a $s_{y.x}$ of 0.17 kg. There was a relationship (P<0.01) between residual and predicted ADG indicating inaccurate prediction. Predicted ADG was able to explain 49% of the variation in predicted ADG error. Observed and predicted ADG means were quite similar with ADG being under predicted with low predictions and over predicted with high predictions. The CCC of 0.20 indicates very weak relationship between observed and predicted ADG with the large TDI_{90} of 0.38 and CP of 70% indicating a lack of precision in ADG prediction.

With 3rd trimester ADG predictions made using actual environmental conditions being positive, this set of data does not provide any additional support to the idea that part of the error in ADG predictions can be specifically attributed to errors in maintenance energy requirement determinations. Additionally, with ADG predicted using actual environmental conditions being either very similar to observed ADG or over predicted, removing the effect of cold environments on the prediction of ADG is not expected to result in improved ADG prediction accuracy or precision. This was case for all three years when evaluated individually or collectively (Table 10) with no relationship (P=0.60 to 0.87) between observed and predicted ADG with predicted ADG explaining <2% of variation in observed ADG in all cases and $s_{y.x}$ of 0.12 to 0.17 kg. Inaccurate prediction was identified based on a relationship (P<0.01 to 0.01) between residual and predicted ADG with predicted ADG explaining 42 to 77% of the variation in ADG prediction error. Gain was generally over predicted in all cases with CCC of -0.01 to 0.02 indicating no relationship between observed and predicted ADG while relative bias square values of 1.25 to 11.79 were all >1 and invalidated the TDI_{90} and CP statistics.

Conclusions

This evaluation of NRC (1996, 2000) model energy requirement and DMI equation for wintering beef cows in western Canada found the equations to lack accuracy and precision in prediction of intake and gain. This situation was not resolved by removing the impact of the environment based adjusters by assuming thermal neutral conditions and calls into question the

practical applicability of the equations for use in beef cow feeding management. There are several possible areas where improvements could be made in the predictions of intake and gain of beef cows. These include development of equations that are more reflective of the limitations to DMI by cows (i.e. fill effects instead of chemo-osmotic effects), maintenance energy requirement equations that are specific to cows instead of using equations adapted from feedlot cattle, and gain prediction equations that reflect that the composition of gain changes with cow condition. These are all issues that have not been addressed in the current energy requirement and intake equations. The inability of the current equations to accurately and precisely predict intake and gain of wintering beef cows should not be viewed as a failure, but rather a success in providing direction for future research. Many of the issues discussed as limitations to the model equations exist only because there is a lack of quality data available for resolving them.

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Table 1. Ingredient and nutrient content of rations[z] fed to wintering beef cows.

	2002-2003		2003-2004		2004-2005	
	2nd trimester	3rd trimester	2nd trimester	3rd trimester	2nd trimester	3rd trimester
Ration ingredients, % of DM						
Alfalfa hay	-	63.1	-	61.5	-	25
Barley grain	-	12.7	-	13.4	-	6
Barley green feed	55.9	-	55.1	-	53	25
Oat straw	44.1	24.2	44.9	25.2	47	44
Nutrient content						
NDF, % of DM	69.3	60.2	69.2	68.8	64.0	67.6
ADF, % of DM	45.4	42.8	44.6	44.0	39.0	42.9
ADL, % of NDF	7.0	8.3	7.7	7.5	8.53	9.68
CP, % of DM	7.7	9.6	6.6	7.6	7.7	7.3
NDIN, % of CP	42.9	49.0	45.5	61.8	18.1	22.9
ADIN, % of CP	31.2	28.1	25.8	28.9	16.5	23.1
EE, % of DM	1.4	1.8	1.6	1.7	2.8	2.5
Ash, % of DM	8.0	8.2	7.6	6.9	5.9	6.3

[z] Commercial 1:1 mineral (Feed-Rite Hi C-N-Z with selenium, Feed-Rite Ltd., Humboldt, SK) containing 160 g kg^{-1} Ca, 160 g kg^{-1} P, 450 mg kg^{-1} Fe, 125 mg kg^{-1} I, 5300 mg kg^{-1} Mn, 4000 mg kg^{-1} Cu, 40 mg kg^{-1} Co, 10 000 mg kg^{-1} Zn, 2000 mg kg^{-1} F, 200 000 IU

kg^{-1} vitamin A, 45 000 IU kg^{-1} vitamin D, and 40 IU kg^{-1} vitamin E, and cobalt iodized salt (Feed-Rite cobalt iodized salt, Feed-Rite Ltd., Humboldt, SK) containing 390 g kg^{-1} Na, 600 g kg^{-1} Cl, 150 mg kg^{-1} I, and 100 mg kg^{-1} Co were provided *ad libitum*.

Table 2. Summary of DMI and ADG prediction inputs (average ± SD) for the 15 pens in each evaluation period of the Saskatoon data set.

	2002-2003		2003-2004		2004-2005	
	2nd trimester	3rd trimester	2nd trimester	3rd trimester	2nd trimester	3rd trimester
DMI, kg d^{-1}	10.93 ± 0.44	12.70 ± 0.90	11.52 ± 0.78	13.63 ± 0.53	13.10 ± 1.03	12.74 ± 0.63
TDN, %	51.74 ± n/a	56.38 ± n/a	49.75 ± n/a	56.38 ± n/a	55.56 ± n/a	61.05 ± 0.97
Temperature, °C						
Previous	-7.2 ± 0.3	-13.8 ± 2.2	-10.9 ± 0.1	-10.2 ± 1.5	1.0 ± 0.0	-15.5 ± 1.1
Current	-9.6 ± 1.4	-10.1 ± 2.6	-11.6 ± 1.3	-8.2 ± 1.1	-11.7 ± 0.5	-5.4 ± 1.8
Wind speed, km h^{-1}	5.0 ± n/a	5.0 ± n/a	5.0 ± n/a	5.0 ± n/a	5.0 ± n/a	5.0 ± n/a
Body condition score, 9-point	5.4 ± 0.2	5.4 ± 0.2	4.7 ± 0.3	5.1 ± 0.3	5.7 ± 0.5	5.7 ± 0.5
Days pregnant	158 ± 5	237 ± 5	164 ± 8	243 ± 4	152 ± 8	233 ± 5
Calf birth weight, kg	45.1 ± 1.7		44.3 ± 2.2		50.0 ± 3.1	
ADG, kg	0.13 ± 0.09	0.00 ± 0.12	0.07 ± 0.12	0.15 ± 0.14	0.39 ± 0.15	-0.1[illegible] ± 0.13

Table 3. Accuracy and precision evaluation results for the 2nd trimester predictions of DMI made using actual environmental conditions.

	2002-2003	2003-2004	2004-2005	All
n	15	15	15	45
Regression of observed vs. predicted				
Intercept ± SE[z]	3.83 ± 10.08	-2.46 ± 26.05	-23.57 ± 10.09	-16.06 ± 2.88
Slope ± SE[z]	0.55 ± 0.78	1.07 ± 1.99	2.63 ± 0.73	2.10 ± 0.22
P-value for regression[y]	0.49	0.60	<0.01	<0.01
R^2	0.04	0.02	0.50	0.69
$s_{y.x}$, kg d^{-1}	0.45	0.80	0.75	0.68
P-value for isopleth[x]	<0.01	<0.01	<0.01	<0.01
Bias, kg d^{-1}	2.01	1.57	0.82	1.47
Mean square error of prediction	4.50	3.23	1.46	2.92
Bias, %	96	80	48	74
Slope, %	0	0	14	10
Correlation, %	4	20	38	16
Regression of residual vs. predicted				
Intercept ± SE[z]	-3.83 ± 10.08	2.46 ± 26.05	23.57 ± 10.09	16.06 ± 2.88
Slope ± SE[z]	0.45 ± 0.78	-0.07 ± 1.99	-1.63 ± 0.73	-1.10 ± 0.22
P-value for regression[y]	0.57	0.97	0.04	<0.00
R^2	0.03	<0.01	0.28	0.37
$s_{y.x}$, kg d^{-1}	0.45	0.80	0.75	0.68
Means comparison				
Observed, kg d^{-1}	10.93	11.52	13.10	11.85
Predicted, kg d^{-1}	12.93	13.09	13.92	13.31
SE[z]	0.08	0.14	0.20	0.14
P-value	<0.01	<0.01	0.01	<0.01
Concordance correlation coefficient	0.01	0.01	0.22	0.24
Precision coefficient	0.19	0.15	0.71	0.83
Accuracy coefficient	0.03	0.05	0.31	0.30
Total deviation index, kg d^{-1}	3.49	2.96	1.99	2.81
Coverage probability, %	2	24	55	29
Relative bias square[w]	18.18	3.59	0.79	2.83

[z] Standard error of the intercept, slope, or least square means.
[y] Significance of the regression relationship between observed or residual and predicted values.
[x] Significance of the test for equality between the fitted regression equation and the isopleth.
[w] Relative bias square must be ≤ 1 for the total deviation index and coverage probability statistics to be valid.

Table 4. Accuracy and precision evaluation results for the 2nd trimester predictions of DMI made assuming thermal neutral environmental conditions.

	2002-2003	2003-2004	2004-2005	All
n	15	15	15	45
Regression of observed vs. predicted				
Intercept ± SE[z]	12.90 ± 1.73	-2.46 ± 26.05	-23.59 ± 9.95	3.15 ± 3.66
Slope ± SE[z]	-0.17 ± 0.15	1.24 ± 2.31	3.06 ± 0.83	0.75 ± 0.31
P-value for regression[y]	0.27	0.60	<0.01	0.02
R^2	0.09	0.02	0.51	0.12
$s_{y.x}$, kg d^{-1}	0.43	0.80	0.75	1.14
P-value for isopleth[x]	<0.01	0.53	<0.01	0.34
Bias, kg d^{-1}	0.70	0.24	1.10	0.21
Mean square error of prediction	1.52	0.65	2.06	1.35
Bias, %	33	8	61	3
Slope, %	56	0	13	1
Correlation, %	12	92	26	96
Regression of residual vs. predicted				
Intercept ± SE[z]	-12.90 ± 1.73	2.46 ± 26.05	23.59 ± 9.95	-3.15 ± 3.66
Slope ± SE[z]	1.17 ± 0.15	-0.24 ± 2.31	-2.06 ± 0.83	0.25 ± 0.31
P-value for regression[y]	<0.01	0.92	0.03	0.43
R^2	0.83	<0.01	0.32	0.01
$s_{y.x}$, kg d^{-1}	0.43	0.80	0.75	1.14
Means comparison				
Observed, kg d^{-1}	10.93	11.52	13.10	11.85
Predicted, kg d^{-1}	11.62	11.29	12.00	11.64
SE[z]	0.16	0.14	0.19	0.14
P-value	0.01	0.25	<0.01	0.28
Concordance correlation coefficient	-0.16	0.03	0.15	0.25
Precision coefficient	-0.30	0.15	0.72	0.34
Accuracy coefficient	0.52	0.21	0.21	0.74
Total deviation index, kg d^{-1}	2.03	1.32	2.36	1.91
Coverage probability, %	55	75	45	60
Relative bias square[w]	0.41	0.08	1.35	0.03

[z] Standard error of the intercept, slope, or least square means.
[y] Significance of the regression relationship between observed or residual and predicted values.
[x] Significance of the test for equality between the fitted regression equation and the isopleth.
[w] Relative bias square must be ≤ 1 for the total deviation index and coverage probability statistics to be valid.

Table 5. Accuracy and precision evaluation results for the 3rd trimester predictions of DMI made using actual environmental conditions.

	2002-2003	2003-2004	2004-2005	All
N	15	15	15	45
Regression of observed vs. predicted				
Intercept ± SE[z]	-11.10 ± 17.92	19.52 ± 15.85	2.18 ± 4.04	5.59 ± 4.74
Slope ± SE[z]	1.78 ± 1.34	-0.44 ± 1.17	0.77 ± 0.29	0.55 ± 0.35
P-value for regression[y]	0.21	0.72	0.02	0.12
R^2	0.12	0.01	0.35	0.05
$s_{y.x}$, kg d^{-1}	0.88	0.55	0.53	0.80
P-value for isopleth[x]	0.04	0.34	<0.01	<0.01
Bias, kg d^{-1}	0.64	0.13	1.02	0.51
Mean square error of prediction	1.17	0.33	1.39	0.92
Bias, %	35	6	79	28
Slope, %	2	9	1	3
Correlation, %	63	85	20	69
Regression of residual vs. predicted				
Intercept ± SE[z]	11.10 ± 17.92	-19.52 ± 15.85	-2.18 ± 4.04	-5.59 ± 4.74
Slope ± SE[z]	-0.78 ± 1.34	1.44 ± 1.17	0.23 ± 0.29	0.45 ± 0.35
P-value for regression[y]	0.57	0.24	0.44	0.21
R^2	0.03	0.10	0.05	0.04
$s_{y.x}$, kg d^{-1}	0.88	0.55	0.53	0.80
Means comparison				
Observed, kg d^{-1}	12.70	13.63	12.74	13.02
Predicted, kg d^{-1}	13.34	13.50	13.76	13.53
SE[z]	0.17	0.10	0.14	0.09
P-value	0.01	0.36	<0.01	<0.01
Concordance correlation coefficient	0.09	-0.04	0.20	0.12
Precision coefficient	0.35	-0.10	0.59	0.23
Accuracy coefficient	0.25	0.42	0.35	0.54
Total deviation index, kg d^{-1}	1.78	0.94	1.94	1.57
Coverage probability, %	61	90	49	69
Relative bias square[w]	0.47	0.05	3.30	0.38

[z] Standard error of the intercept, slope, or least square means.
[y] Significance of the regression relationship between observed or residual and predicted values.
[x] Significance of the test for equality between the fitted regression equation and the isopleth.
[w] Relative bias square must be ≤ 1 for the total deviation index and coverage probability statistics to be valid.

Table 6. Accuracy and precision evaluation results for the 3rd trimester predictions of DMI made assuming thermal neutral environmental conditions.

	2002-2003	2003-2004	2004-2005	All
n	15	15	15	45
Regression of observed vs. predicted				
Intercept ± SE[z]	7.07 ± 3.17	19.52 ± 15.85	7.21 ± 4.88	13.20 ± 2.17
Slope ± SE[z]	0.47 ± 0.26	-0.51 ± 1.36	0.44 ± 0.38	-0.01 ± 0.18
P-value for regression[y]	0.10	0.72	0.28	0.94
R^2	0.20	0.01	0.09	<0.01
$s_{y.x}$, kg d^{-1}	0.84	0.55	0.62	0.82
P-value for isopleth[x]	0.01	<0.01	0.35	<0.01
Bias, kg d^{-1}	0.71	1.99	0.06	0.92
Mean square error of prediction	1.40	4.55	0.42	2.03
Bias, %	37	92	1	43
Slope, %	15	1	14	25
Correlation, %	48	7	85	33
Regression of residual vs. predicted				
Intercept ± SE[z]	-7.07 ± 3.17	-19.52 ± 15.85	-7.21 ± 4.88	-13.20 ± 2.17
Slope ± SE[z]	0.53 ± 0.26	1.51 ± 1.36	0.56 ± 0.38	1.01 ± 0.18
P-value for regression[y]	0.07	0.29	0.17	<0.01
R^2	0.24	0.09	0.14	0.43
$s_{y.x}$, kg d^{-1}	0.84	0.55	0.62	0.82
Means comparison				
Observed, kg d^{-1}	12.70	13.63	12.74	13.02
Predicted, kg d^{-1}	11.99	11.64	12.67	12.10
SE[z]	0.23	0.10	0.14	0.11
P-value	0.03	<0.01	0.75	<0.01
Concordance correlation coefficient	0.33	-0.01	0.28	-0.01
Precision coefficient	0.44	-0.10	0.30	-0.01
Accuracy coefficient	0.74	0.02	0.93	0.56
Total deviation index, kg d^{-1}	1.95	3.51	1.07	2.34
Coverage probability, %	57	5	85	49
Relative bias square[w]	0.51	11.24	0.01	0.70

[z] Standard error of the intercept, slope, or least square means.
[y] Significance of the regression relationship between observed or residual and predicted values.
[x] Significance of the test for equality between the fitted regression equation and the isopleth.
[w] Relative bias square must be ≤ 1 for the total deviation index and coverage probability statistics to be valid.

Table 7. Accuracy and precision evaluation results for the 2nd trimester predictions of ADG made using actual environmental conditions.

	2002-2003	2003-2004	2004-2005	All
n	15	15	15	45
Regression of observed vs. predicted				
Intercept ± SE[z]	0.19 ± 0.06	0.14 ± 0.06	0.13 ± 0.07	0.21 ± 0.02
Slope ± SE[z]	0.25 ± 0.23	0.22 ± 0.15	0.54 ± 0.15	0.38 ± 0.04
P-value for regression[y]	0.30	0.18	<0.01	<0.01
R^2	0.08	0.14	0.52	0.69
$s_{y.x}$, kg	0.09	0.11	0.10	0.10
P-value for isopleth[x]	<0.01	<0.01	<0.01	<0.01
Bias, kg	0.37	0.40	0.09	0.23
Mean square error of prediction	0.16	0.21	0.03	0.13
Bias, %	91	82	30	42
Slope, %	4	12	30	50
Correlation, %	5	6	39	8
Regression of residual vs. predicted				
Intercept ± SE[z]	-0.19 ± 0.06	-0.14 ± 0.06	-0.13 ± 0.07	-0.21 ± 0.02
Slope ± SE[z]	0.75 ± 0.23	0.78 ± 0.15	0.46 ± 0.15	0.62 ± 0.04
P-value for regression[y]	0.01	<0.01	0.01	<0.01
R^2	0.45	0.67	0.43	0.86
$s_{y.x}$, kg d^{-1}	0.09	0.11	0.10	0.10
Means comparison				
Observed, kg	0.13	0.07	0.39	0.19
Predicted, kg	-0.24	-0.33	0.48	-0.03
SE[z]	0.03	0.04	0.04	0.05
P-value	<0.01	<0.01	0.17	<0.01
Concordance correlation coefficient	0.03	0.08	0.60	0.50
Precision coefficient	0.29	0.37	0.72	0.83
Accuracy coefficient	0.12	0.21	0.84	0.60
Total deviation index, kg	0.66	0.75	0.27	0.58
Coverage probability, %	18	23	86	49
Relative bias square[w]	7.95	3.82	0.37	0.67

[z] Standard error of the intercept, slope, or least square means.

[y] Significance of the regression relationship between observed or residual and predicted values.

[x] Significance of the test for equality between the fitted regression equation and the isopleth.

[w] Relative bias square must be ≤ 1 for the total deviation index and coverage probability statistics to be valid.

Table 8. Accuracy and precision evaluation results for the 2nd trimester predictions of ADG made assuming thermal neutral environmental conditions.

	2002-2003	2003-2004	2004-2005	All
n	15	15	15	45
Regression of observed vs. predicted				
Intercept ± SE[z]	0.13 ± 0.03	-0.02 ± 0.05	-0.04 ± 0.11	0.06 ± 0.03
Slope ± SE[z]	-0.06 ± 0.11	0.40 ± 0.22	0.56 ± 0.14	0.38 ± 0.05
P-value for regression[y]	0.62	0.09	<0.01	<0.01
R^2	0.02	0.20	0.54	0.54
$s_{y.x}$, kg d^{-1}	0.10	0.11	0.10	0.13
P-value for isopleth[x]	<0.01	<0.01	<0.01	<0.01
Bias, kg d^{-1}	0.04	0.15	0.39	0.16
Mean square error of prediction	0.07	0.04	0.18	0.09
Bias, %	3	55	90	30
Slope, %	85	17	4	53
Correlation, %	12	28	6	17
Regression of residual vs. predicted				
Intercept ± SE[z]	-0.13 ± 0.03	0.02 ± 0.05	0.04 ± 0.11	-0.06 ± 0.03
Slope ± SE[z]	1.06 ± 0.11	0.60 ± 0.22	0.44 ± 0.14	0.62 ± 0.05
P-value for regression[y]	<0.01	0.02	0.01	<0.01
R^2	0.87	0.36	0.43	0.76
$s_{y.x}$, kg d^{-1}	0.10	0.11	0.10	0.13
Means comparison				
Observed, kg d^{-1}	0.13	0.07	0.39	0.19
Predicted, kg d^{-1}	0.09	0.21	0.78	0.36
SE[z]	0.05	0.03	0.04	0.04
P-value	0.52	<0.01	<0.01	0.01
Concordance correlation coefficient	-0.10	0.26	0.19	0.51
Precision coefficient	-0.14	0.45	0.74	0.73
Accuracy coefficient	0.68	0.57	0.25	0.70
Total deviation index, kg d^{-1}	0.43	0.33	0.70	0.50
Coverage probability, %	61	77	16	57
Relative bias square[w]	0.02	1.07	7.62	0.40

[z] Standard error of the intercept, slope, or least square means.
[y] Significance of the regression relationship between observed or residual and predicted values.
[x] Significance of the test for equality between the fitted regression equation and the isopleth.
[w] Relative bias square must be ≤ 1 for the total deviation index and coverage probability statistics to be valid.

Table 9. Accuracy and precision evaluation results for the 3rd trimester predictions of ADG made using actual environmental conditions.

	2002-2003	2003-2004	2004-2005	All
n	15	15	15	45
Regression of observed vs. predicted				
Intercept ± SE[z]	0.04 ± 0.03	0.15 ± 0.05	-0.10 ± 0.04	0.00 ± 0.03
Slope ± SE[z]	0.36 ± 0.12	-0.02 ± 0.28	-0.19 ± 0.24	0.17 ± 0.13
P-value for regression[y]	0.01	0.96	0.44	0.18
R^2	0.41	<0.01	0.05	0.04
$s_{y.x}$, kg d^{-1}	0.10	0.14	0.14	0.17
P-value for isopleth[x]	<0.01	0.01	<0.01	<0.01
Bias, kg d^{-1}	0.10	0.01	0.21	0.03
Mean square error of prediction	0.04	0.04	0.10	0.06
Bias, %	26	0	48	2
Slope, %	51	50	37	48
Correlation, %	23	50	19	50
Regression of residual vs. predicted				
Intercept ± SE[z]	-0.04 ± 0.03	-0.15 ± 0.05	0.10 ± 0.04	0.00 ± 0.03
Slope ± SE[z]	0.64 ± 0.12	1.02 ± 0.28	1.19 ± 0.24	0.83 ± 0.13
P-value for regression[y]	<0.01	<0.01	<0.01	<0.01
R^2	0.69	0.49	0.66	0.49
$s_{y.x}$, kg d^{-1}	0.10	0.14	0.14	0.17
Means comparison				
Observed, kg d^{-1}	0.00	0.15	-0.12	0.01
Predicted, kg d^{-1}	-0.10	0.14	0.09	0.04
SE[z]	0.05	0.03	0.04	0.03
P-value	0.13	0.80	<0.01	0.42
Concordance correlation coefficient	0.46	-0.01	-0.10	0.20
Precision coefficient	0.64	-0.01	-0.22	0.20
Accuracy coefficient	0.72	0.99	0.47	0.97
Total deviation index, kg d^{-1}	0.32	0.31	0.51	0.38
Coverage probability, %	77	78	54	70
Relative bias square[w]	0.31	0.00	0.73	0.02

[z] Standard error of the intercept, slope, or least square means.
[y] Significance of the regression relationship between observed or residual and predicted values.
[x] Significance of the test for equality between the fitted regression equation and the isopleth.
[w] Relative bias square must be ≤ 1 for the total deviation index and coverage probability statistics to be valid.

Table 10. Accuracy and precision evaluation results for the 3rd trimester predictions of ADG made assuming thermal neutral environmental conditions.

	2002-2003	2003-2004	2004-2005	All
n	15	15	15	45
Regression of observed vs. predicted				
Intercept ± SE[z]	-0.01 ± 0.06	0.12 ± 0.18	-0.02 ± 0.17	0.04 ± 0.06
Slope ± SE[z]	0.03 ± 0.15	0.05 ± 0.31	-0.14 ± 0.26	-0.05 ± 0.11
P-value for regression[y]	0.85	0.87	0.60	0.67
R^2	<0.01	<0.01	0.02	<0.01
$s_{y.x}$, kg d^{-1}	0.12	0.14	0.14	0.17
P-value for isopleth[x]	<0.01	<0.01	<0.01	<0.01
Bias, kg d^{-1}	0.30	0.43	0.77	0.50
Mean square error of prediction	0.16	0.23	0.69	0.34
Bias, %	59	85	93	75
Slope, %	31	6	4	17
Correlation, %	10	9	3	8
Regression of residual vs. predicted				
Intercept ± SE[z]	0.01 ± 0.06	-0.12 ± 0.18	0.02 ± 0.17	-0.04 ± 0.06
Slope ± SE[z]	0.97 ± 0.15	0.95 ± 0.31	1.14 ± 0.26	1.05 ± 0.11
P-value for regression[y]	<0.01	0.01	<0.01	<0.01
R^2	0.77	0.42	0.60	0.67
$s_{y.x}$, kg d^{-1}	0.12	0.14	0.14	0.17
Means comparison				
Observed, kg d^{-1}	0.00	0.15	-0.12	0.01
Predicted, kg d^{-1}	0.30	0.58	0.66	0.51
SE[z]	0.05	0.03	0.04	0.03
P-value	<0.01	<0.01	<0.01	<0.01
Concordance correlation coefficient	0.02	0.01	-0.01	-0.01
Precision coefficient	0.05	0.05	-0.15	-0.06
Accuracy coefficient	0.34	0.14	0.06	0.23
Total deviation index, kg d^{-1}	0.65	0.79	1.36	0.96
Coverage probability, %	41	17	1	19
Relative bias square[w]	1.25	5.06	11.79	2.84

[z] Standard error of the intercept, slope, or least square means.

[y] Significance of the regression relationship between observed or residual and predicted values.

[x] Significance of the test for equality between the fitted regression equation and the isopleth.

[w] Relative bias square must be ≤ 1 for the total deviation index and coverage probability statistics to be valid.

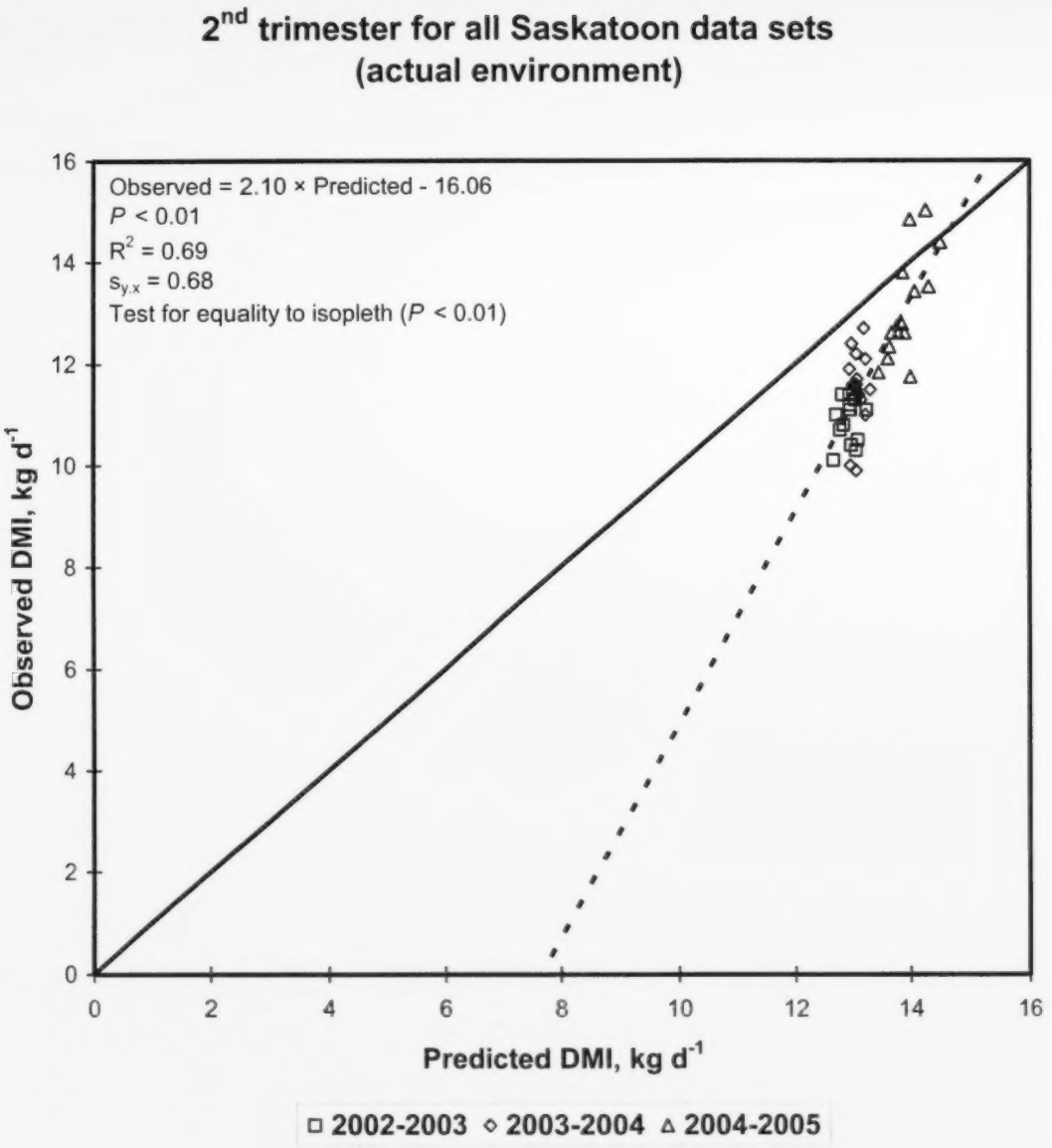

Figure 1. Evaluation the NRC (1996, 2000) model DMI equation accuracy under the actual environmental conditions of the 2nd trimester evaluation period for the 2002-2003, 2003-2004, and 2004-2005 winter feeding trials. Each point represents one pen of six cows. The solid line represents the isopleth (Y=X) line that would indicate accurate prediction. The dashed line represents the fitted regression equation for which the equation, fit statistics, and test for equality to the isopleth are shown.

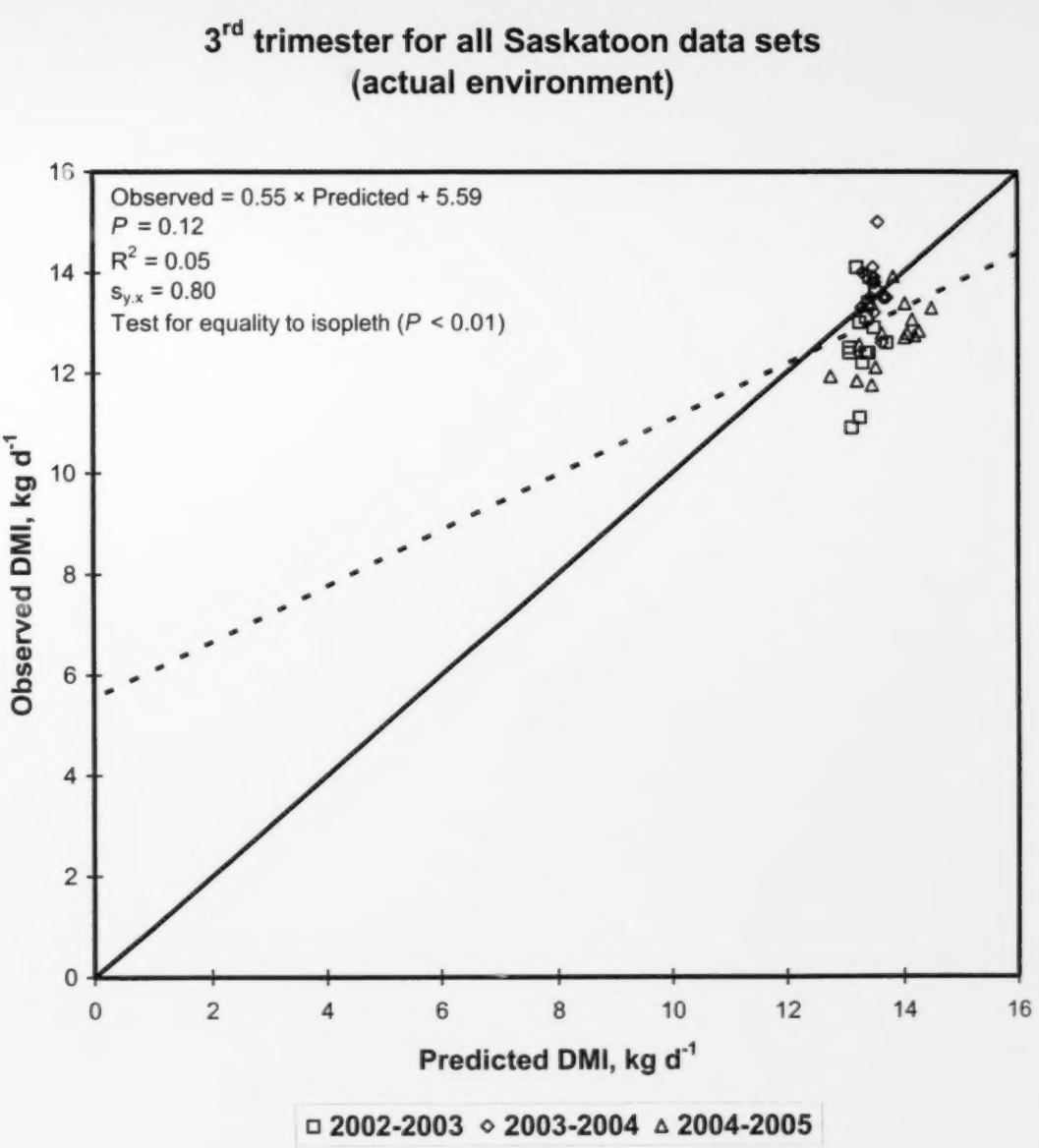

Figure 2. Evaluation the NRC (1996, 2000) model DMI equation accuracy under the actual environmental conditions of the 3rd trimester evaluation period for the 2002-2003, 2003-2004, and 2004-2005 winter feeding trials. Each point represents one pen of six cows. The solid line represents the isopleth (Y=X) line that would indicate accurate prediction. The dashed line represents the fitted regression equation for which the equation, fit statistics, and test for equality to the isopleth are shown.

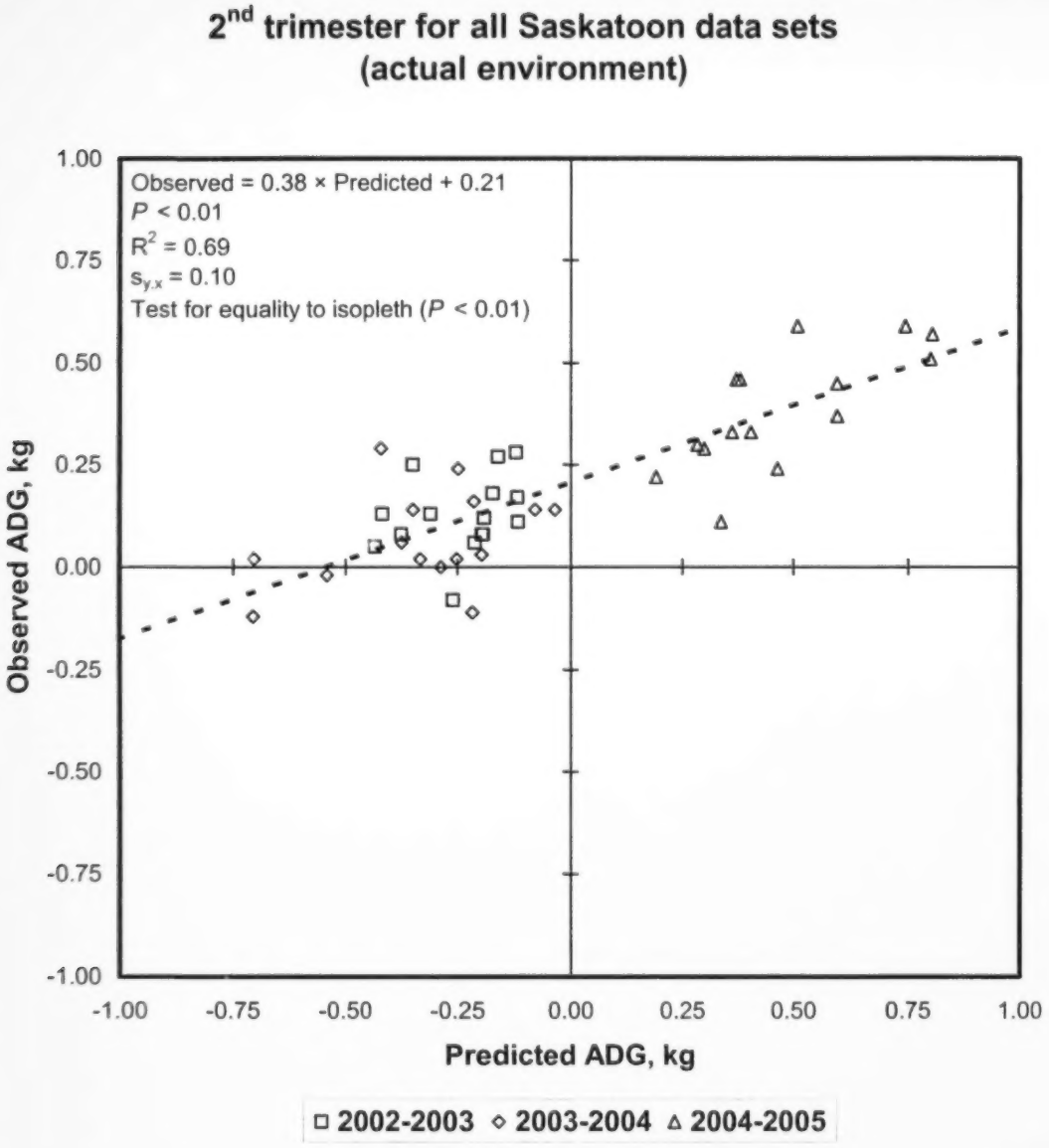

Figure 3. Evaluation the NRC (1996, 2000) model ADG equation accuracy under the actual environmental conditions of the 3rd trimester evaluation period for the 2002-2003, 2003-2004, and 2004-2005 winter feeding trials. Each point represents one pen of six cows. The solid line represents the isopleth (Y=X) line that would indicate accurate prediction. The dashed line represents the fitted regression equation for which the equation, fit statistics, and test for equality to the isopleth are shown.

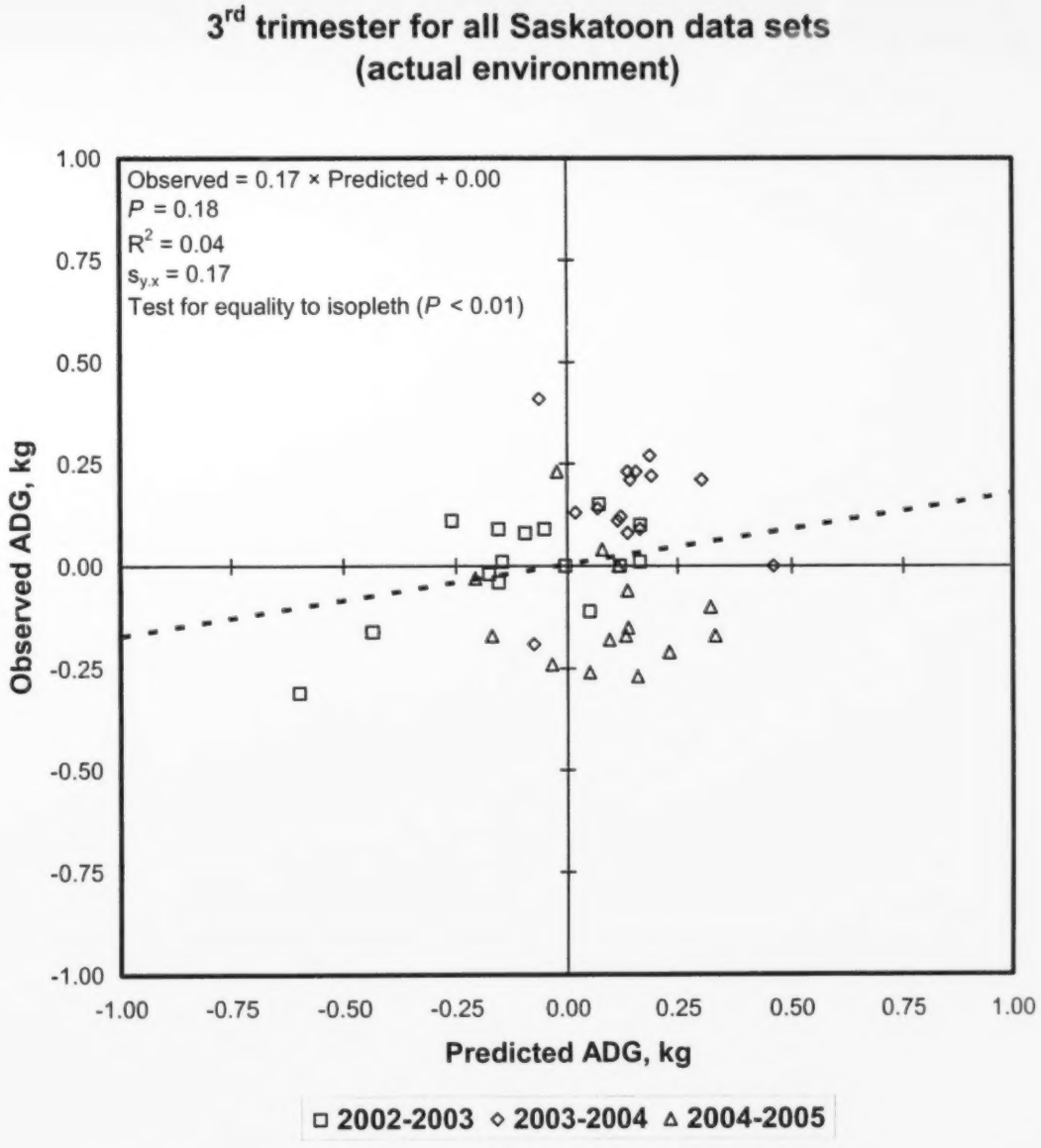

Figure 4. Evaluation the NRC (1996, 2000) model ADG equation accuracy under the actual environmental conditions of the 3rd trimester evaluation period for the 2002-2003, 2003-2004, and 2004-2005 winter feeding trials. Each point represents one pen of six cows. The solid line represents the isopleth (Y=X) line that would indicate accurate prediction. The dashed line represents the fitted regression equation for which the equation, fit statistics, and test for equality to the isopleth are shown.